SCIENTIFIC AMERICAN SUPPLEMENT

VOLUME LXXVIII
NUMBER 2034
NEW YORK, DECEMBER 26, 1914
10 CENTS A COPY
$5.00 A YEAR

All that remains of a grand peristyle of fifty-four columns.

LOFTY PILLARS OF GREAT TEMPLE, BAALBEK.—[See page 407.]

The Psychanalytic Movement—II*

Its Services in the Prevention of Insanity

By James J. Putnam, M.D.

Concluded from SCIENTIFIC AMERICAN SUPPLEMENT No. 2033, Page 391, December 19, 1914

As illustrative of the kind of service that education can sometimes render, even to very young children, through planting the seeds of the broader sense of social obligations which is so favorable to mental solidarity and health and so hostile to the dissociation that is brought about by repression, I will mention an observation, superficially trivial, but suggestively important.

A small child, who had fallen into habits of theft, became strongly captivated by the idea, which was carefully presented to him, that he could take "with his eyes," instead of with his hands, the things that he longed to appropriate, and thus gain, ideally, the satisfaction of possession, reinforced by the gratification of satisfying a dim social ideal, although obliged to renounce the pleasure of exclusive ownership,[5] with its denial of the social principle. Subsequent developments indicated that this discovery, which appealed, perhaps, primarily, to his imagination only, helped to effect a real change of temperament.

The educational system that has elaborated most thoroughly the methods of inducing or emphasizing this community sentiment as a goal of progress, and has placed them on a practical footing for children between 4 and 6 years old, is undoubtedly the kindergarten system of the great thinker and educator Friedrich Froebel. Kindergartens do not by any means always come up to his ideals, but one cause of this lies in the failure of parents and their advisers to recognize the part which this system aims theoretically to play, and in their failure to give an adequate support to those who are working toward this end.

It is, however, not enough to admit the importance of a general preparatory training of this sort, even if it could be supposed that its principles were to be emphasized through the discipline of the home.

Each child has his own special needs, to be met by appreciative sympathy, direction and correction, and these needs are to be best understood when they are studied in the light of a knowledge of those to whom the tendencies to represssion, dissociation, and ambivalence have gone on to a more or less excessive degree.

A certain amount of repression, dissociation, and ambivalence seems to be an inevitable attendant of competitive existence; but it has not been appreciated until recently at what an early stage in the child's life these tendencies may appear. It is true that, with the majority of children, neither repression nor dissociation nor the tendency to primary or reactive emotional excess that leads to these results, is developed to any very objectionable extent. Children of the best sort, no matter how childlike and, for a time, immature their traits may be, appear to be marked by a characteristic quality that stamps every act as belonging in part to a maturer future of which it may be said to be prophetic, while, perhaps on that very account, it appears also to belong peculiarly to the present moment.

Nevertheless, the pitfalls into which so many children actually stumble (not so much because they are degenerate in the sense of having progressive brain defects, as because their power of adaptation is insufficient for the requirements of life in a given environment) should be recognized as standing open for even the most broadly adaptable child. The earliest years of all children are years of self-engrossment, the finding of themselves in the sensations that attend their reflex acts, their impulses, the recognition of their powers, desires and fears, and as reflected in the attention of their parents. And this period is beset from the outset with the danger that these new-found gratifications and excitements will be taken too exclusively in and for themselves.

The engrossment of these primary, primitive, and elemental pleasures—which soon become modified by the comparisons which children institute between themselves and others, and the instructive discovery of their capacity for compensations and over-compensations—is then more or less superseded by the engrossments of their powers of fantasy, through which the unpleasant realities of the social life, for which they are still unprepared, can be shoved off for a time, in the interest of a more unified life of imagination.

Hand in hand with this tendency comes the recognition of the possibility of repressing what is too distressing, coupled with that of preserving the pleasurable aroma even of excitements that might be reckoned painful.

And here begins the double life of which every child lover should be able to see the traces and the dangers, and also the possibilities of added usefulness.

Children outgrow, it is true, vast numbers of habits which they are tempted to adopt in these earlier years, and it is as objectionable to see signs of permanent mischief in incidental tendencies as it is to overlook their psychologic significance. One may be trustful, but should none the less be watchful.

The principal dangers to which parents are exposed are of a twofold sort. First, they may fail to get any adequate idea of the process which is going on in the child's mind. Next, they may fail to recognize that each child, at each stage of his existence, is instinctively trying to construct a species of unified world, and is using therefor a set of symbolisms which must, perforce, be based on the sensations which he gets from his own efforts and functions, however foreign and trivial, or even revolting, the language of these symbolisms may seem to the adult.

Finally, they may let the desire to seek their own gratification (even though unconsciously) stand in the way of the best interests of the child.

This latter danger is important and familiar, and although not difficult to understand is very difficult to avoid. The love of the parent for the child usually means great devotion; but this is too often given for the sake of a return in kind, and it then partakes of the character of self-love, or mirror love. This sort of devotion fetters the child instead of making him more free, whereas really disinterested love increases the child's independence by arousing in him a corresponding disinterestedness on his part, in a form suitable to his age.

The parent should be a bridge over which the child may pass to a social existence of a wider sort, carrying habits and tendencies of loyalty and service, and feeling within himself a foreshadowing sense of the larger community of which he is to become a part. But, instead, it too often happens that the father or the mother, by dint of the very exclusiveness and intensity of their own affection and the fascination of its exhibition, creates or intensifies a similar exclusiveness in the child's mind, and thus chains him to a set of private gratifications which become sensuous and exacting in proportion as they are asocial. The "father-complex" and "mother-complex" have played with good reason a large part in psychanalytic writing, as in life.[6] Repeatedly have I seen lives that should have been eminently happy threatened with unhappiness through influences like those which I have outlined.

Another important principle which everyone should know is that the fantasies and desires of children, even when their object is something which to the adult seems insignificant or unworthy, have meanings which *come near* to being good and useful meanings, and may by chance be transformed by good management into something useful and creative.

The intelligent parent will seek to see through the act or the symbol, and to appreciate the child's meanings. These meanings should be divined through real sympathy, based on close but intelligent intimacy, and should be taken at their best value.[7] For it may depend on the turn of this straw whether a desirable outcome finally emerges or whether the act or interest that might have served a good turn as a symbol and then have been replaced, becomes, through repression, the center of a hampering craving. The tendency to relieve, in later years, the fantasy-life of self-indulgent childhood may arise from either of two sorts of causes; an excessive preference for the self-indulgent pleasures first exhibited at an early period when another and better choice might perhaps have been made with almost equal willingness; and a tendency to regression toward these renounced but simpler pleasures, showing itself under conditions of fatigue and strain from which every person seeks instinctively to escape. The child should be protected as far as practicable from both of these dangers, first through having ample inducements offered him for making the best choice, and, next, through being taught to do well and easily the tasks that he is to be called on to do.

In other words, his incitements to the best choice (as, especially, through the imitation of living and historic characters, and through examples afforded by literature), his adaptations and his adaptability should all be held in mind, and with special reference to the specific sorts of dangers that he must encounter.

The imagination of the young child is a weapon of immense power for evil or for good. It can be turned to the support of the reason or to the intensification of sense cravings.

The supplementary addition which I propose to this educational scheme is one that in a certain sense restores the ambivalent principle, as one that when rightly understood is broader than even the principle of independence and power, as commonly conceived. The best man—or child—is not alone a single individual; he is likewise a member of a community, or series of communities, eventually of an ideal community of some sort to which he feels that his loyalty is due and to which he becomes rebound. Similarly, just in proportion to the degree that a man makes himself independent of narrowing ties such as imply slavish dependence, whether based on fear or favor, or longing for approbation and attention, or jealousy or envy, and becomes in that sense independent, he becomes once more dependent on the obligations imposed by his own good qualities and powers, according to the principle hinted at by the term "*noblesse oblige*."

If such a person frees himself from the objectionable and hampering features of his childhood, he should retain, nevertheless, and all the more, the best that his childhood stands for, thus expressing, in his life, all that "religion" literally taken, indicates, namely, a rebinding accompanied by a setting-free. Nothing less than this sort of ambivalence should be, I think, the goal of education for the normal and the neurotically disposed child. This sort of rebinding which should show itself able to meet, at least fairly well, any ordinary test of genuineness is also a goal aimed at theoretically by the educational system of Froebel. It is, of course, not to be supposed that a couple of years even in the best kindergartens, much less in any given school which bears that name, is to be reckoned as a sure prevention against subsequent psychoses, any more than it is to be supposed that every person of the type to which I have above alluded as the best in kind is to be considered as, *ipso facto*, beyond the reach of these dangers. The causative factors ordinarily involved are far too numerous for that, but one reason that I rate so high the possibilities of this system is that, while it aims to use all obvious means for the development of character without needlessly calling the conscious attention of the child to this aim, it recognizes also the importance of taking some measures to prepare the child, through very simple investigations into the results of his own acts, for making labor, even if still only in a simple form, that kind of rational self-scrutiny which psychanalysts have learned to look on as of so much value.

One of the most obvious fruits of this rational self-scrutiny is that—contrary to the usual belief—it is destructive of that morbid, emotional self-scrutiny that goes by the name of introspection and that shows itself so often as a sign and a promoter of the neurotic disposition. I am not wedded to any one plan of education, however, and should welcome any scheme that could show evidences of its capacity to develop character, self-reliance, and the recognition of community obligations.

Let it not be supposed, however, that this claim can without further inquiry, be made for any and every system that makes a great point, with quasi-military vigor, on the overcoming of difficulties just for their own sake. This has its value, but it is a value that can easily be estimated too highly. After all, it is the personality and previous training of the teacher that are the elements of chief importance. But every such teacher should have been taught to accept a hint from the experience of the psychanalyst, and to use not only general but specific means to make his personality eventually unnecessary to his pupils. The importance of following this rule was pointed out by the able Mme de Stiel, as a consideration worthy the attention of every legislator.

---

* Abstract of a paper read before the Section on Nervous and Mental Diseases at the Sixty-fifth Annual Session of the American Medical Association, Atlantic City, N. J.

[5] I am not attempting here a complete explanation of theft-habits, certain roots of which have been shown by psychanalysis to be very deeply rooted in infantile instincts.

[6] Compare papers by Abraham and by Jung in the Jahrb. f. Phychoanul. u. Psychopathol. Forsch., I, 110, 155.

[7] Compare R. L. Stevenson's Lantern Bearers.

"Heads and Tails" and Heredity*

Statistical Methods Which May Assist in the Study of New Problems

The mysteries of heredity have always attracted men of science and men in general. The theory of evolution has explained some of these mysteries, but it has also brought forward new problems, which are still far from solution. The object of this paper is to show the usefulness, in the study of these problems, of certain methods which are called statistical methods and which are based on simple arithmetical deductions from the results of games of chance. In this way we shall learn how it is possible to enunciate, with confidence, laws applying to complex phenomena which we are unable to study in detail.

In many cases we are not interested in the details, and desire only the general result. The wheat grower, for example, cares only for the total quantity and average quality of his crop, not for the individual peculiarities of each grain. This is not quite true of the problems of human heredity, for each child is of supreme importance in the eyes of his parents. Nevertheless, if the average quality of the race can be improved by methods of social hygiene that do not interfere with legitimate individual liberty, the result will have a social value independent of individual advantages. It is worth while, therefore, to apply the statistical method even to those problems of heredity in which the individual point of view possesses the greatest importance.

How can it be easier to solve a complex problem than a simple one? How can ignorance in regard to the simple problem lead to certainty in regard to the complex problem? The answer is given by a study of the commonest and simplest game of chance, "heads and tails."

If a coin is tossed and I wager that it will fall with the head side up, everybody will agree that I have an even chance of winning. If the throw is repeated I again have an even chance of winning, and so on, indefinitely, for the result of any single throw cannot be affected by

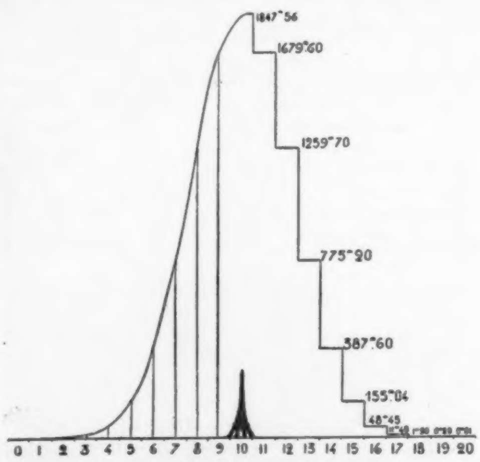


Fig. 3.—Possibilities of twenty throws.

The steps at the right correspond to the piles of Figs. 1 and 2. At the left the steps are replaced by a curve drawn through their middle points. The curve, compared with the Eiffel Tower, shows how large a drawing like Fig. 1 would be.

the preceding throws. As Joseph Bertrand said, the coin has neither conscience nor memory. Yet if we should be told that heads had been thrown fifty times in succession, the result would appear so improbable that we should question the fairness of the play. Here our ignorance of the result of a single throw does not prevent our firm conviction that fifty consecutive throws cannot be won honestly. In order to test the legitimacy of this conclusion, let us consider all of the possibilities presented by a series of throws.

If there is only one throw, there are only two possible alternatives: head or tail. If there are two throws, each alternative of the first throw may be combined with each alternative of the second throw. Hence there are four possible combinations (head-head, head-tail, tail-head, tail-tail) only one of which contains two heads. If a third throw is added, each of its alternatives may be combined with each of these four couples, producing eight possible triple combinations, only one of which contains three heads. Continuing this process we find that the number of possible combinations is doubled by each additional throw, but that only one combination is composed entirely of heads. The possibilities of three, four and five throws are illustrated in Fig. 1, and those of eight throws in Fig. 2. The corresponding drawing for twenty throws would contain more than twenty million circles, and would fill a sheet of paper more than a mile long if the circles were one centimeter (.04 inch) in diameter. Fig. 3 gives an idea of the size of such drawing, in comparison with the Eiffel Tower. To express the possibilities of 100 throws, supposing that 100 combinations could be indicated on an octavo page, would require 10^{25} volumes of 1,000 pages, which would weigh nearly as much as the earth. Of this vast number of combinations one only would represent the case in which heads are thrown 100 times in succession. This combination is as likely to occur as any other definite combination, for example, that of heads in all odd throws and tails in all even throws. The combination last mentioned, however, is but one of a very large number, each of which gives 50 heads in 100 throws.

These examples show that the laws of chance confirm the statement that exceedingly improbable events never occur. To take another illustration from Joseph Bertrand, it will never happen that a particular paving stone in a city square remains dry after a whole day of rain, although there is no reason why any individual drop should fall on that stone, rather than on the next one.

Let us apply these principles to certain phenomena of heredity, which are called Mendelian, because they were first observed by an Austrian monk, named Mendel. Suppose the individuals of a species of animals or plants are of two kinds, which we may call white and black. The distinction may, or may not be, one of color but, for the sake of brevity, we give the name "white" to individuals possessing a certain character, and the name "black" to individuals possessing the opposite character.

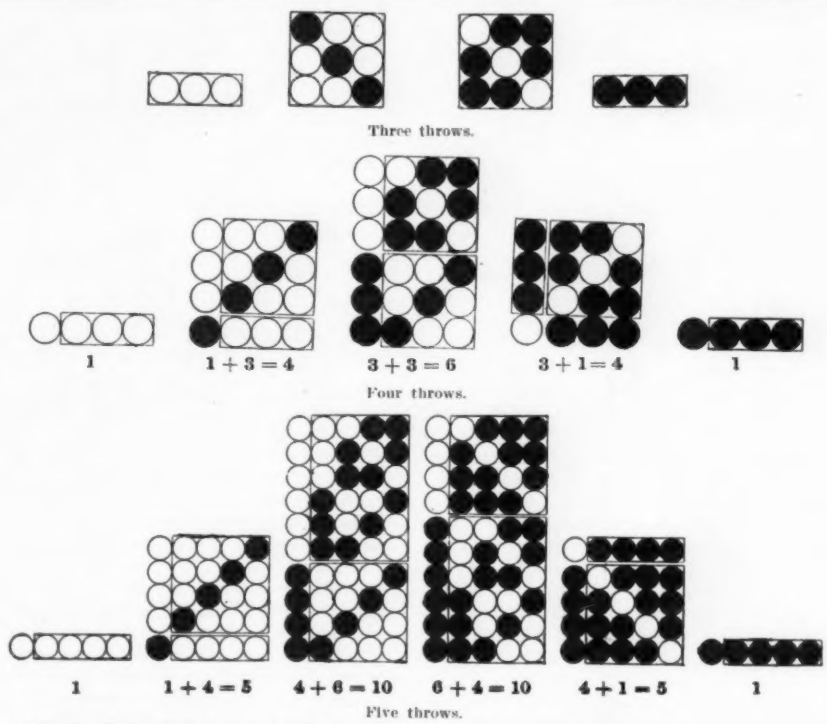


Fig. 1.—Possibilities of three, four, and five throws in "heads and tails."

Each possible combination is represented to a row of circles white for heads and black for tails. Rows having the same number of white circles are arranged in a pile which comprises as many rows as there are combinations containing that number of heads.

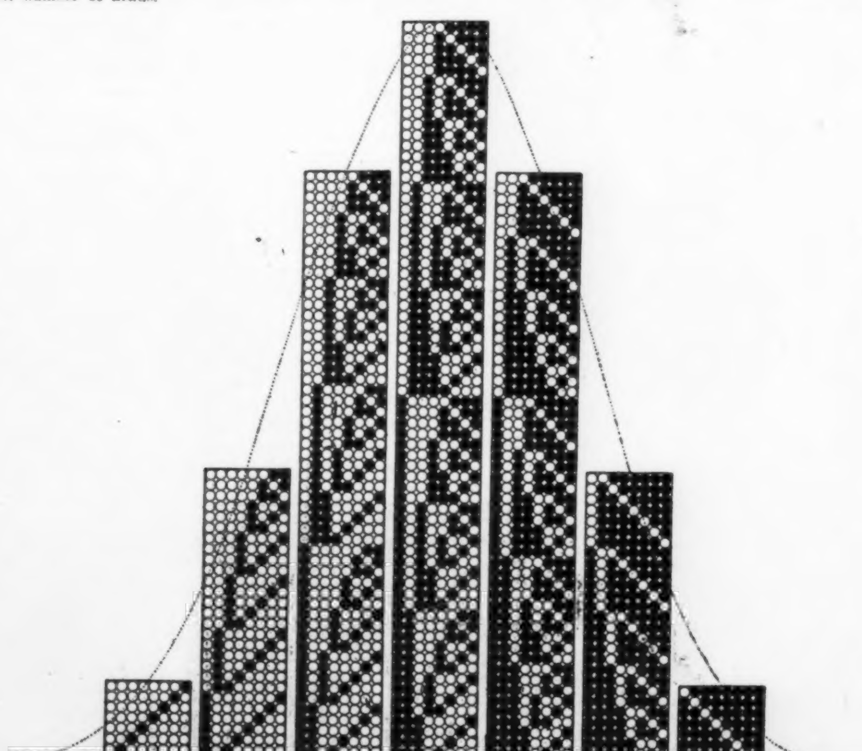


Fig. 2.—Possibilities of eight throws.

*Adapted from Prof. Émile Borel's article in *La Science et la Vie*.

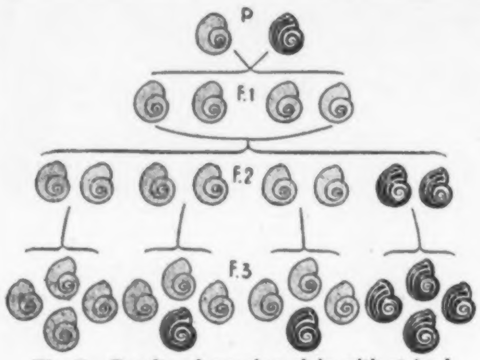


Fig. 7.—Results of crossing plain with striped snails.

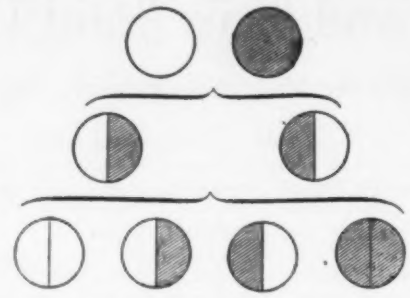


Fig. 4.—Diagram illustrating Mendel's law.

Fig. 6.—Forms of cocks' combs that obey Mendel's law of heredity.

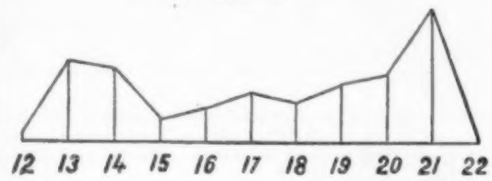


Fig. 10.—Curve representing the number of flower sets of chrysanthemum segetum.

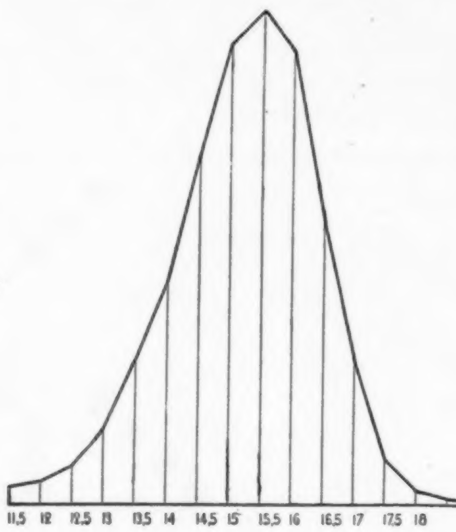


Fig. 9.—Curve of percentage of sugar in beets.

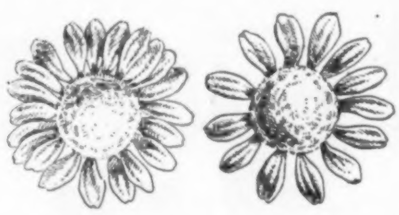


Fig. 12.—Two pure races of chrysanthemum segetum obtained by selection.

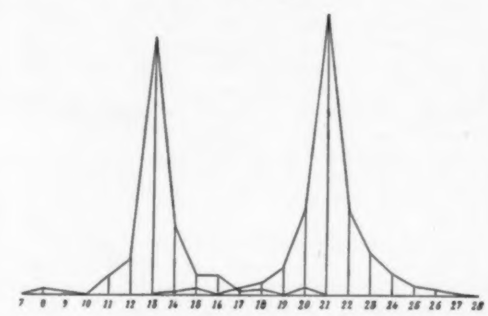


Fig. 11.—Curves of pure races of chrysanthemum segetum.

These characters are called Mendelian if they appear, in successive generations, in the following way:

The crossing of white with black individuals produces hybrids which, in appearance, are like their white parents—a fact which is expressed by saying that the white character is "dominant" and the black character is "recessive." When these apparently white hybrids are crossed among themselves, however, one fourth of the offspring is black. These facts are illustrated by Fig. 4, in which the original pure white and pure black individuals are represented by the top row of circles, the first hybrids by the middle row, and the offspring of crosses of these hybrids by the bottom row. The result is the same as would be obtained by combining in every possible way the white and the black semicircles of the middle row.

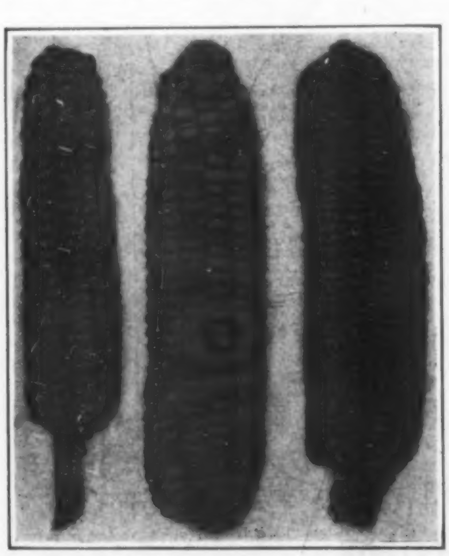


Fig. 5.—Result of crossing smooth and wrinkled varieties of corn.

Just as, when a coin is thrown twice, there are four possible combinations, head-head, head-tail, tail-head, and tail-tail, each of white is equally likely to occur, so when two white-and-black hybrids are crossed, an average group of four offsprings will include one white-white or pure white, one black-black or pure black, and two white-and-black hybrids. As the white character is dominant these hybrids will apparently be white so that, if the observed results are simply recorded without interpretation, the record will show 75 per cent whites and 25 per cent of blacks. The fact that crosses between whites and blacks yield 100 per cent of whites, while crosses between these young whites produce 25 per cent of blacks is certainly very remarkable, and it would be incomprehensible without the explanation given above.

Mendel's laws have been tested by many experiments, especially in the case of plants, from which it is comparatively easy to obtain numerous descendants. Fig. 5 shows two ears of maize, with smooth and wrinkled kernels respectively, and between them an ear of the second cross, with about 75 per cent of its kernels smooth, and 25 per cent wrinkled.

Experiments with animals, continued through many generations, require great care and an extensive establishment. In four years Prof. Rabaud has used more than 30,000 mice in a research that is still in progress. Fig. 6 shows forms of cocks' combs that appear to be transmitted according to Mendel's law. Fig. 7 is a schematic representation of results obtained with snails. The common garden snail occurs in two varities, having respectively plain and striped shells. When these varieties are crossed (*P*, Fig. 7) all of their immediate progeny, constituting the first daughter generation (F_1), have plain shells, as the plain character is dominant. Crosses among these young snails (F_1) produce the second daughter generation (F_2) of which 25 per cent have striped shells, and 75 per cent have plain shells. The plain-shelled snails of this generation (F_2), however, are only apparently alike. One third of them (constituting 25 per cent of F_2) produce plain shells exclusively in the next generation (F_3), while the others (constituting 50 per cent of F_2) produce plain and striped shells in the ratio of 3 to 1. The striped snails that constitute the remaining 25 per cent of F_2 produce striped shells exclusively in the third generation (F_3).


Fig. 8.—Radiographs of hands with abnormally short fingers.

In the course of generations the Mendelian combinations become very complex, especially when the species possesses several characters that follow Mendel's law. These combinations are governed by the same arithmetical laws that apply to the game of "heads and tails," and they may be represented by diagrams analogous to Figs. 1, 2 and 3.

Hence the bell-shaped curve of Fig. 3 is again encountered in the study of heredity.

Mendel's laws may explain certain phenomena of atavism, i. e., the occurrence in a child of characters not shown by its parents but conspicuous in a more remote ancestor. In this way a better understanding of some observed facts may be obtained, but the conclusions that have been derived are based on arguments that are very delicate and sometimes contestable, as Dr. Guyénot has shown. Similar objections apply to theories of sex, regarded as a Mendelian character. For certain malformations that occur frequently in some families the


Some of the cages in which the mice, used in the experiments of Mr. Rabaud, live.

observed facts are not sufficiently numerous to prove conclusively that the malformation is a Mendelian character. An example is furnished by brachydactylism, or shortness of fingers (Fig. 8).

In plants it has been found possible to obtain very definite results, of great practical value, which forecast the results that may be expected from such extensive and well planned experiments with animals as those which M. Rabaud is conducting.

When the statistics of a large crop are arranged with reference to the occurrence of a particular character, the bell-shaped curve of Fig. 3 will usually be found. Fig. 9, for example, indicates the percentages of sugar in a crop of 40,000 beets. The number of beets yielding each percentage is proportional to the height of the vertical line marked with that percentage. This number increases and then diminishes as the percentage steadily increases, and is greatest for the mean percentage, 15.5

In some cases the curve shows two maxima. The Dutch botanist Hugo de Vries, celebrated for his researches on heredity and mutation in plants, counted the flowerets in each flower head of 97 plants of *chrysanthemum segetum*. The results are shown in Fig. 10, in which the height of each vertical line indicates the number of plants which bore flowers containing the number of flowerets marked at the base of that line. The curve shows two maxima, at 13 and 21. The seed of the plants which bore heads of 13 flowerets were collected and sown. The seedlings bore a large proportion of heads of 13 flowerets. By repeating this process of selection regular single-maximum curves were obtained in several successive years. An analogous result was obtained by selecting seeds of plants that bore heads of 21 flowerets. In this way two pure and distinct races, one with 13 and the other with 21 flowerets, were isolated. The curves for these races are shown, partially superposed, in Fig. 11, and typical flowers of the two varieties are illustrated in Fig. 12.

In this instance the isolation of pure races possesses only theoretical interest, but similar methods have been employed with success for the improvement of important agricultural products. One of the most curious cases is that of barley. The modern brewing industry demands barley of uniform quality. The employment of grain of different sorts involves tentative methods and disappointments. The required uniformity has been obtained by selecting seed in the manner described above. This result, first obtained in Sweden, marks the most notable success that has been attained by the application of statistical methods to problems of heredity and demonstrates some of its practical values.

The achievements of such triumphs requires long and patient labor. The statistical theory of biological phenomena is not yet fully developed and it will be many years before all of the results which we are justified in expecting shall have been attained. Meanwhile it appears useful to point out the mathematical resemblance between the problems of heredity and those of games of chance. Mathematicians are sometimes blamed for wasting their energies on problems of no practical importance, and the reproach seems especially well deserved when their researches are devoted to games of chance. We have found, however, that the laws of chance apply to biological phenomena, besides dominating the modern physical theories which are rapidly increasing our knowledge of the nature of matter and energy.

Light Power Excavators

There are innumerable small undertakings where earth must be moved, such as sewers, drainage ditches, building roadbeds, and even light dredging, where an ordinary steam shovel cannot be conveniently utilized, and where hand labor is so expensive as to be discouraging. Such work is largely of the kind that is required of township and drainage boards, and a cheap and efficient method for doing this class of excavation not only makes improvements possible in small communities, but encourages such enterprises.

With a view to meeting requirements of this kind the light utility excavator shown in the illustration has been devised, which is operated by a crude oil engine, and is so light that it can be easily handled on any class of work. As the construction is so arranged that the framework can be easily taken apart, the whole outfit can be conveniently transported and set up anywhere by only a few men, and when once located on a piece of work it is self propelling. Besides the nature of the mounting that is arranged to span wide ditches, the chief difference between this outfit and an ordinary steam shovel lies in the fact that a long boom is used, and it is also possible to use a much longer dipper handle; and these differences not only enable deeper excavations to be made, but the excavated material can also be deposited at greater distances on either side. The oil engine power plant is also found much more convenient to operate with the average crew used for this kind of work than steam, and no licensed engineer is required.

The illustration shows the excavator digging a large tile trench for drainage, in which work it has proved very economical, and it is also valuable for constructing irrigation canals, and keeping them cleared. Dredging, stripping, construction work and the handling of sand or concrete are other lines of work to which it has been applied.

This machine is light in construction, easily dismantled or assembled, and can be transported on wagons over country roads. It spans the ditch or other excavation or can be mounted on a float. The dredge is of steel construction, and the forward end of the structure is carried on four heavy, double flange steel wheels, arranged in patented swiveling two-wheel trucks. The rear end is carried on two similar wheels, one on either side, loose fitted on axles, allowing ample side play for uneven tracks. The dredges are built to span ditches of various widths and are fitted with special extension axles giving a maximum adjustment of three feet. A suitable number of sections of portable track are employed with each machine.

As above mentioned, where the working conditions make it necessary, the entire framework and machinery can be mounted on a float and operated with equal efficiency. The motions of hoisting, swinging, and traveling are operated by friction clutches and controlled with powerful foot brakes. The operating levers are conveniently located in front of the operator, and arranged so one man can easily handle all operating and brake levers without changing his position. The operator stands well forward where he commands a free and clear view of his work at all times.

It is of interest to note that the power for operating is supplied by an oil engine of proper capacity for operating all motions, either independently or simultaneously. The dipper is constructed with detachable teeth and a quick release bottom dump. The operator has perfect control of the dipper and dipper arm, and very high speeds can be attained.

At Essexville, Mich., one of these oil dredges, having a 32-foot gage, 39-foot boom, one-yard dipper, and 25 horse-power oil-burning engine, was able in a 10-hour day to handle 600 to 900 yards of dirt with 25 gallons of oil.

At another place one of these oil dredges was set up on five pontons each 12 feet long, 8 feet wide, and 3½ feet deep, and it has done some most important dredging work in a very economical manner.

The Detroit, Bay City & Western Railroad Company completed about three miles of railroad grade with one of these oil dredges, and it is stated by those engaged in the work that they could not have built a grade through this particular part of the country without a machine of the kind. The territory covered is practically all swamp, and the water stands above the top of the ground in many places. They averaged about 300 feet of roadbed every 12 hours, and put up an embankment each day containing about 600 cubic yards. Extra help was required in making a runway for the dredge, as it was necessary to move most of the way on poles or corduroy on account of the extreme softness of the ground.

Light, portable utility excavator operated by an oil motor, shown at work on a drainage ditch.

Correspondence

[The editors are not responsible for statements made in the correspondence column. Anonymous communications cannot be considered, but the names of correspondents will be withheld when so desired.]

Power Required to Stop an Automobile

Editor of the SCIENTIFIC AMERICAN SUPPLEMENT:

In two recent issues of the SCIENTIFIC AMERICAN I note that there have been three solutions of the problem in the July 4th issue, which problem was stated:

"What horse-power would it take to stop an auto in 30 feet running 20 miles per hour and weighing 3,500 pounds?"

In the three solutions above referred to, each varies from the others in the time required to stop the car. It will be noted and admitted by all that this matter of time is the unknown factor in the case, inasmuch as the horse-power required to stop the car in any distance is dependent only upon the time.

I submit the following solution, which agrees with none of the three heretofore published, and yet, without desiring to give the impression of egotism in the slightest degree, I believe this solution to be correct.

SOLUTION.

From the formula $K = \frac{w\,v^2}{2g}$ we have

$$K = \frac{3500 \times 29.3333^2}{64.32} \text{ or } \frac{3500 \times 29.34^2}{64.32} = \frac{3012924.6}{64.32} =$$

46842.7 *F. P.* of kinetic energy stored in car.

$\frac{46842.7}{30} = 1561.4$ pounds = weight required to stop car in 30 feet.

In order to find horse-power kinetic energy must be expended in a given time, i. e., $T = \frac{D}{0.65v} = \frac{30}{19.064}$ = 1.57 seconds time required to stop car.

Therefore, $\frac{46842.7}{1.57 \times 550} = \frac{46842.7}{863.5} = 54.2$ *H. P.* answer.

But $T = \frac{wv^2}{H.P.\,550\,2g} = \frac{D}{0.65v}$. Therefore

$$T^2 = \frac{wv^2D}{H.P.\,550\,2g\,0.65v} \text{ or } T = \sqrt{\frac{wv^2D}{H.P.\,550\,2g\,0.65v}} =$$

$$\sqrt{\frac{90387728}{36522419.33}} = \sqrt{2.46} = 1.57 \text{ seconds, approx.}$$

Or $D = \frac{H.P.\,T^2 550\,2g\,0.65v}{wv^2} = \frac{90378257.4}{3012924.0}$ feet approx.

which proves the above theoretically. To prove whole solution note diagram. To construct square as shown, *PORZ*, to any convenient scale, in this case, 1 inch = 1 second per ten miles per hour per 14.6666 feet per second.

Let the line *PZ* scale the vel. in feet per second, and *PO* scale speed in miles per hour.

Since in this case the car traveled 30 feet before stopping, from any point on the line *PZ* lay off 30 feet, say from *d* to *c*. Using *d* as a center with a radius equal to *dc*, lay off *da*, which will be equal to and at right angles with *dc*. Then draw *ac*, which is the base line to the time curve. It will thus be seen from this that the base line of the time curve is dependent only on the distance which the car traveled in stopping.

Since the power applied to stop the car is constant, the decrease in speed will be uniform throughout.

From the formula $T = \frac{D}{0.65v}$ reduce 0.65 to a fraction which is 13/20. Therefore, lay off *ac* into 20 equal parts. Then combine the 20 equal parts into 5 parts with a uniform decrease, which will be 6/20, 5/20, 4/20, 3/20, and 2/20. Therefore, let *ae* equal 6/20 of *ac*; *ef* equal 5/20 of *ac*; *fg* equal 4/20 of *ac*, etc., down, which gives a uniform decrease.

From the points *efgh*, just located, drop the lines *gA*, *fB*, etc., perpendicular to *dc*. From *b* on *bc* lay off *bE* equal to *Dc*; *EF* equal to *CD*, etc. Erect perpendiculars at *E*, *F*, *G*, etc., and project *Ae*, *Bf*, etc., until they intersect, which will be at points *i*, *k*, *l*, *m*. Through these points draw the curve *aiklmc*, which is the time curve of the problem with a length of 3.14 inches. Referring to the time scale for 20 miles per hour we find 2 inches = to 1 second of time in time curve. Therefore, $\frac{3.14}{2} = 1.57$ seconds, which is the time it took car to stop as previously stated.

Let *da* equal foot-pound scale equal 46,842.7 foot-pounds. Lay off on *da*, *ds*, *st*, etc., all equal. Therefore, *ar* equals 9,368.54 foot-pounds; *ru* equals 9,368.54 foot-pounds, etc. At the points *r*, *u*, etc., erect perpendiculars to the line *ad*. Project them until they intersect base line *ac*, which will be at points *s'*, *u'*, *t'*, and *w'*. From these points erect perpendiculars to the line *ac* and project them until they intersect the curve *aklc*, which will be at points *i*, *k*, *l*, *m*.

Then scale *ai*, which, in this case, is 0.314 second. In that interval the car travels from *d* to *a*, which scales 9 feet.

From the formula horse-power $= \frac{K}{T550}$ we have horse-power $= \frac{9368.54}{0.314 \times 550} = 54.2$ horse-power, which proves the above.

Let ax = velocity scale, i. e., 29.3333 miles per hour scaled to base line. Angle, *xac* = right angle and *ax* = *ac*. Then project *Dm*, *Cl*, etc., until they intersect *ax*, which will be at *x''*, etc.

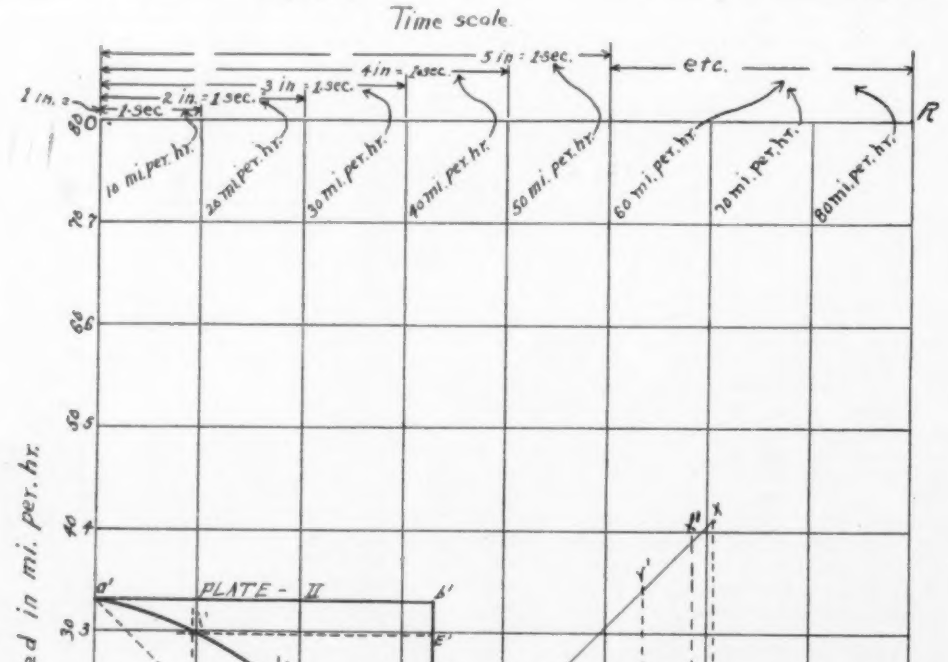
Using *a* as a center, imagine the curve *aklc* swung around until it terminates at *x* instead of *c*. Then *Ai*, *Bk*, etc., would be ordinates of the time curve *akix*. From the ordinates given, find the mean ordinate, which, in this case, will have a length of *P'o'*. Project the line *P'o'* so that it will lie perpendicular to *ab* and its ends will terminate in *ax* and *ab*. Now then, the triangle *v'ax'* = *xv'x'b*, and the mean velocity = *av'* which scales 13/20ths of *ax*, or 19.064 miles per hour.

Hence, the formula $T = \frac{D}{0.65v}$ It will be readily seen from the diagram that the mean velocity, and not one half the velocity, or the average velocity, must be used in finding the time.

Note.—Original lines showing projection not left lest diagram be confusing to reader.

Plate II is an illustration of how the time curve would be drawn when the number of feet traveled is less than the velocity. In this case velocity = 60 miles per hour. Distance stopped equals 50 feet. Proceed same as in Plate I. Lay off 50 feet on *PZ* from *P* and also 50 feet on *PO* from *P*. Draw *a'c'* and proceed with time curves same as in Plate I. But velocity = 60 miles per hour. Note time scale, 6 inches = 1 second. Then 6 inches on the curve *a'k'l'c'* would equal 1 second of time.

W. T. FRANCIS.



Magic Squares.

To the Editor of the SCIENTIFIC AMERICAN SUPPLEMENT:

I have been much interested, and so have several other engineers here in the graphic solutions for magic squares as worked out by Mr. A. R. Kennedy in the SUPPLEMENT for October 3rd.

Many years ago I worked out a method by which I could write the numbers consecutively into any square

17	24	1	8	15
23	5	7	14	16
4	6	13	20	22
10	12	19	21	3
11	18	25	2	9

Begin always with 1 in top center square. 2 always goes at bottom of next righthand column. Write always to the right and diagonally upward. When the last righthand column has been reached, begin at the lefthand column one row higher. Whenever a multiple of the side of the square is reached drop one space vertically for the next number and write diagonally as before. Variations are, of course, possible.

of odd orders, the method being made plain, I think, by the two illustrations given herewith. I did not at that time succeed in evolving a similar method for squares of even order, and have never since had leisure to try it further. Perhaps Mr. Kennedy, or some one else, would be interested in trying it out.

47				1	12	23	34	45
			9	11	22	33		
		8	10	21	32		54	
	7	18	20	31				
6	17	19	30					
16	27	29	40					5
26	28	39					4	15
36	38					3	14	25
37	48				2	13	24	35

When once the method is grasped, a magic square of any odd order may be made as fast as one can write the figures.

W. G. SWART.

Mechanical Traction in War

In such arduous work the mortality among the vehicles is heavy, more especially in the case of the German army, which uses a heavier vehicle than is thought advisable elsewhere. The German unit of 4-ton motor truck with 2-ton trailer weighs, when fully laden, about 13 tons—a load heavy to draw on muddy roads cut about by hard service, and dangerous for the smaller bridges and culverts. The difficulty of using such heavy vehicles must grow as the winter comes on, especially in operations on the Russian frontier, where they can scarcely prove otherwise than entirely useless on the primitive dirt roads of the region.

A motor wagon, capable of carrying a net load of 3 tons, will probably weigh, when fully laden, not less than 6¾ tons, and of this at least 4 tons, if not 5, will come on the rear axle. It is necessary, in fact, to expect axle loads of 5 tons. Any road to be capable of taking ordinary motor traffic must be able to stand such a load; even heavier axle loads are supportable, provided the wheels and tires are suitably chosen, but at this point a further factor comes in—viz., the ability of bridges and culverts to carry vehicles of this weight.

In order to enable very heavy vehicles to travel at all on really soft ground it is necessary for them to carry their own track with them. In "caterpillar" tractors, as one class of these vehicles is called, a long band of flat jointed blocks runs around each lateral pair of road wheels; the blocks lie on the ground and the wheels run along a steel race on the inner sides of the blocks. In this way a very large bearing surface is obtainable, but as few of such vehicles have been built there is little experience available as to their durability under the heavy conditions in which they are designed to operate.

The German wagons have been experimented with for all sorts of heavy military work. A simpler way of employing the same principle is the use of what are known as "girdle" plates. These are flat plates of wood or metal girdling each individual road wheel; they were employed on the Boydell traction engine as long ago as the Crimean war, and are now used on some of the heavier German field guns; thus the 11.2-inch Krupp siege howitzer, firing a shell of 760 pounds, is described as being mounted on wheels 6 feet in diameter, having girdle plates attached, so giving a large bearing surface on the ground for the heavy load of 7½ tons which each wheel has to carry when the gun is in the firing position.

The 16-inch German siege howitzer, of which so much has been heard, is stated on good authority to weigh no less than 20 tons, exclusive of its cradle, carriage, etc. Now a load of this weight laden on a road vehicle could scarcely with the vehicle weigh less than 30 tons, and it is difficult to imagine any such load being taken far by road, not so much because of the smashing of the road foundations (which might perhaps be avoided by the extensive use of the methods above mentioned) as because of the risk of breakage of bridges and culverts. Railway bridges and culverts are able easily to deal with loads far greater than these, and to any point which railways reach there should be little difficulty in carrying these guns; but on roads in general this seems out of the question. But such efforts have probably been made, and later on, when the history of what has been done with motor transport in this war comes to be written, it will be specially interesting to see to what extent they met with success.—*The London Times.*

Mysterious Baalbek

Whose Magnificent Temples Show the Hands of Many Ages and Nations

By Mrs. Thomas E. LePage

There is little or no authentic record of Baalbek before the Roman era, yet around and about Lebanon and the Valley of Coele-Syria, the propylaea as it were to Syria proper and biblical history from Baal and Sun Worship to the Sea of Galilee and the Nazarene, have occurred some of the most engrossing events of history. In this scenario, covering over 115,000 square miles and over 2,000 years, Baalbek boldly played a part, as is evidenced in the remains of her splendid temples, the ruins of her palaces and the color of her legends; and while not remote, as distances are measured or dates reckoned, all that remains of Baalbek is a broken seam-scarred city, set apart and unchronicled save in the carvings of her ruined shrines.

From earliest times Syria was an object of prize to the foreign nations without and within her border, and desultory warfare between the tribes made impossible any coalescence of her states. This internal struggle was partly due to her natural environs; the mountain ridges and rivers dividing the country into isolated valleys, plains, and plateaus make a close relationship unnatural and maintain barriers to the adjustment of petty disputes and grievances.

The borderlands are protected from the encroachment of the desert by a continuous chain of lakes and beds of reeds. The Lebanon ranges extend from southwest to northeast in parallel ridges inclosing the valley of the Coele-Syria, that famous plain of Buka'a (mulberry), whose fertile soil has nourished the peoples who despoiled her. Anti-Lebanon, "Lebanon toward the sun rising," begins in the plateau of Bashan and extends north to Mount Hermon, "the tower of Lebanon, which looketh toward Damascus." From Hermon it runs northeast and declines into the plain of Emesa. This range, especially bleak in its scant growth of juniper and dwarf oak, slopes on the west abruptly into Buka'a. Radiating from Hermon on the east are three transverse ridges which form the walls of the terraces. The Phoenician Plain, two miles at its widest, lies at the base of Lebanon on the west. These slopes are cultivated in every crevice of the rock where grow the mulberry and vine, and in the glens below dense groves of olive.

To escape the perils of the Syrian desert the narrow valley became the tramping-ground of conquest, civilization, and trade on its march east and west. Baalbek (ancient Heliopolis) lies off the main roads connecting Damascus with the coast, or with the other cities celebrated in the story of Syria, and this fact accounts in part for the provincialism of to-day. Where the valley opens into the foothills of anti-Lebanon and the plain of Emesa stands Baalbek at the head of that great natural rift that marks the watercourse of Syria. At an elevation of 4,500 feet the city occupies a position similar to that of the Aeropolis at Athens. There are the remains of a city wall two miles in circumference, portions of which are of Phoenician origin. Under Alexander the Great the city rose to a high degree of civilization. Augustus made it a Roman colony and placed there a garrison. John of Antioch mentions the Great Temple as built by Antoninus Pius, and names it as one of the wonders of the world. Later it was converted into a Christian church by Theodosius. The temple is said to have contained a golden statue of Apollo, or Zeus, which the citizens would bear about on their heads on certain festival days. There must also have been an oracle of fame at Baalbek, for Trajan is said to have visited it prior to his Parthian campaign.

The Arabs conquered the city in 636, in 1139 and again in 1260 the place was captured by Mongols. In 1400 Baalbek surrendered to Tamerlane on his march from Hums to Damascus, and the city was completely pillaged. From this period the decline was rapid. During the Crusades the city was the scene of constant strife.

The Great Temple was counted a work of Solomon by the inhabitants, and some maintain he built the city as a residence for the Queen of Sheba, but of this there is no historic record. The platform and substructure bear inscriptions, now illegible, pointing to a date earlier than that of Antoninus Pius. Coins of the time of Septimus Severus display a temple with portico and ten columns in front, and another coin has a temple with many columns in the peristyle and steps leading from the side. The architecture on both coins is of the same period.

Syria bears traces of the mythology of Egypt, and Macrobius in his Saturnalia mentions how, in very remote times, priests from On built a Temple to the Sun at Heliopolis in Lebanon, for Sun worship enjoyed high rank at Baalbek. Julia Domna, empress of Septimus Severus, was the daughter of Bassianus, priest of the Sun at Emesa (Hums); and Helogabalus, a priest of the Sun in the same city, became emperor and assumed title "Invictus Sacerdos Augustus Sacerdos Dei Solis." Worship of Venus also prevailed at Heliopolis.

Under Constantine Christianity was established, and a check was put upon the ancient faith. An imperial rescript was issued warning the people against the excesses of their rites, and admonishing them to accept Christianity. A basilica was erected, and a bishop and his presbyters consecrated. With Julian the Apostate the place again reverted to Baal, and the Christians, banished from Alexandria, were sent to Heliopolis, from where they were distributed to the mines. Theodosius destroyed the temples and fanes and converted the trilothon into a Christian church.

In the seventh century Mohammedanism descended upon Syria, and Damascus, Heliopolis, and other cities became subject to foreign rule. For three centuries following there are no chronicles of Baalbek.

With its appearance the name is changed to Baalbek[1], and the temple was converted into a fortress and used as a defense against the Fatimite Kaliphs of Egypt. Two Arabian chroniclers mention Baalbek in the middle of the tenth century. Ibn Haukal writes in the middle of the tenth century: "Here are gates and palaces, sculpture in marble, lofty columns also of marble, and in the whole region of Syria there is not a more stupendous or considerable edifice." Edrise, an ancient geographer during the twelfth century, mentions the temples and refers to the tradition which regards them as of the time of Solomon. Benjamin of Tudela mentions stones of enormous size laid up without cement.

[1] The probable etymomlogy would read:
[*Baal*, god of Sun = *Helion*, lord of Sun: + *bek* < Ar. Bakka, compressed, thronged = Baal's throng or place of gathering].
A second etymology which has been suggested [*bek* < Eygptian Baki, city] accords with Heliopolis, but the admixture of foreign tongues is without analogy. The Frank historians write it Malbec.

Of the present-day Baalbek there is little to relate. The few hundred houses are encircled by a wall nearly two miles in circumference. The population is about 2,000 and made up of several religious sects, one quarter being Christians. It is the seat of a Bishopric of the Greek Catholic Church, and contains three churches, four mosques, six schools, and four monasteries as well as a Turkish bath, three hotels and an Arab Kahn.

The quarries lie within a half mile of the ruins, and from them the huge foundation blocks were doubtless taken. The size of these can be appreciated by the measurements of a detached block, which is 68 feet 4 inches in length, 17 feet 2 inches wide, and 14 feet 7 inches high, a bulk of 17,000 cubic feet, and weighing perhaps 1,500 tons. In another quarry there is a defective obelisk 98 feet long. The only specimen known to exceed these Baalbek stones is the dolmen at Antegnera, measuring in bulk 33,000 cubic feet.

In Syria, where wood was scarce, the native basalt was used extensively in doors, shutters, floors, and roofs, and the technique of masonry became more developed than in any other part of the Roman world.

This famous group of ruins, comprising the Temple of Bacchus, a smaller circular temple to Venus, and the far-famed Temple of the Sun, stands upon a shored acropolis overlooking the town, the Lebanon ranges and the waterways leading into the Valley of Jordan and the Land of Galilee. The Great Temple, with its mighty sub-basement, subterranean vaults that underlie half the city, the immense courts, propylaea and steps unexampled in the history of ancient architecture are of solidity and proportion that seem to prophesy the destiny of races and the progress of nations. In plan and decoration the Greek and Roman dominate, although many ages have contributed less directly.

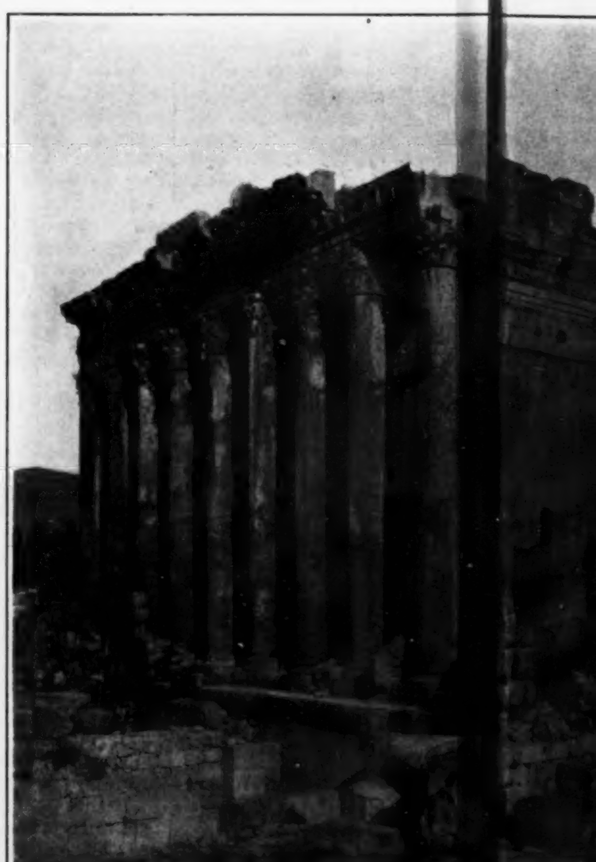
While dependent upon the Etruscans and Greeks for their principles of architecture it was left to Roman engineering to supply the principles of construction to the more complicated problems such as the great spans of dome, vault, and arch. Here the Roman genius excelled as witnessed in the massive barrel vaulting of the Great Temple, the only other example of which on so large a scale being the Temple of Venus and Rome. The hexagonal forecourt, flanked by halls, leads into the Great Court, where stands the Altar of Burnt Sacrifice and the Basin of Lustration, concealed by Theodosius' basilica and only recently uncovered. This court is also flanked by a series of halls, rich in carving and varying in size, and once ornamented with statues. The Temple of the Sun is approached by stairs leading from the west side of the main court. This temple, covering an area of four acres, was originally encircled by a peristyle of fifty-four columns, of which six alone in the southern rank are standing. These shafts measure 60 feet in height, are 7½ feet in diameter, and are constructed each of three blocks of rough unhewn stone, the Romans invariably using the fluted column when the material was not granite or porphyry. The capitals and entablature are richly carved with acanthus leaves. A frieze of lion's heads, a cornice and molding complete the architrave; and it is here that the Roman offends in the redundant display of Corinthian ornature, overstepping in his application of decorative art the standards of taste that the Greeks have established and devotedly observed.

Interior of the Temple of Bacchus at Baalbek. Note tablet to the German Emperor.

Great court in the temple in which stood [...]o the Sun

Baalbek and Its [...]ifice[...] of [...]ery

Immense monolith lying in a quarry at Baalbek. Similar stones were used in the foundations of the temple.



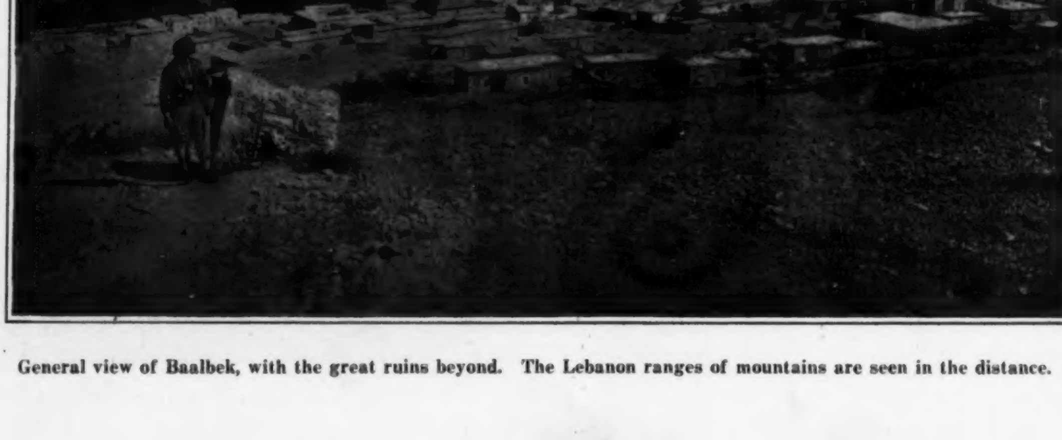
Exterior of th[...]Bacchus.

n stood o the Sun, and the Basin of Lustration.

ts ificent Temples of ery

ior of th Bacchus.

Richly carved portal of the Temple of Bacchus.



General view of Baalbek, with the great ruins beyond. The Lebanon ranges of mountains are seen in the distance.

Every member of the decoration of the temple suggests a function, and is least elaborate where the strain is greatest. But it is in the interior of the Temple of Bacchus where the zeal of the artists runs riot in such a mass of ornate detail that one sighs for the works of Ictinus and the chaste columns of the Parthenon.

In the north wall of the Bacchus interior the inscribed tablet recording the German Emperor's visit to Baalbek is plainly visible.

The arcading, in which the Roman excels, is exemplified in the circular Temple of Venus, a form borrowed from the Etruscans. This example is noticeable for its pentagonal bases, four-columned portico and the heavy entablature of Corinthian ornament overhanging carved architraves. There is the usual peristyle of columns added by the Romans, a distinctive departure evidently regarded as an improvement.

The mythology of Syria is the history of an intensified and prolific age in which parthenogenesis was the impelling idea. The fish, symbol of progeny, is the popular emblem. It has been said that in Greece "the myths are luminous, harmonious, in Egypt maintaining an appearance of wisdom even when most fantastical," but in Syria "they seem to whirl as the simoon of the desert."

Three impressions remain after reviewing these monuments: First, the sense of solidarity and proportion expressed in the massive masonry; second, the ravish display of Corinthian ornature, so luxuriant, sumptuous, sensuous in its exquisite beauty of concept and form that the eye were pained and the mind repelled did not there come lastly that charm ineffable, the secret of Sun worship. A gorgeous burst of purple flame and gold, softly, swiftly, triumphantly, immaculately sweeping that broken pile, the historic record of many races.

Making long neon tubes.

Making electric and photometric measurements of neon tubes.

Neon Light Tubes

By Jacques Boyer

A PECULIARLY striking example of the fruitfulness in practical results which is attached to scientific researches carried on primarily from a purely academic interest is presented by the case of neon. This gas was first recognized as one of the constituents of the atmosphere by Ramsay. It will be remembered that his classical researches had their inception in the observation that atmospheric nitrogen had a slightly greater density than nitrogen prepared from other sources. Hence an impurity was suspected in atmospheric nitrogen, and systematic investigation did reveal such an impurity in the so-called "rare" gases of the atmosphere, which constitute about one per cent of its total volume.

Now these rare gases, one and all, have a peculiarity that at first sight would seem to render them ill adapted for practical uses; they are exceedingly inert, and utterly refuse to enter into any chemical combination. It appears hopeless, therefore, to expect any use for them except in their elementary form.

Yet one of them, neon, does possess physical properties which render it peculiarly adapted for a specific use: A "vacuum" tube, the residual gas of which consists of neon, has been found by the French physicist Claude to offer a peculiarly low resistance to the passage of an electric discharge therethrough; on this basis an electric lighting system of high efficiency has been developed.

The neon is obtained in a state of great purity by fractional liquefaction of air, of which it constitutes one part in sixty-six thousand Using a liquefaction plant having a working capacity of 50 cubic meters of liquid oxygen per hour, 100 liters of neon can be obtained per day, and this is sufficient for the manufacture of 1,000 neon tubes of 1,000 candle-power each.

One of the principal difficulties encountered in the manufacture of neon light tubes is the fact that mere traces of nitrogen and especially of hydrogen very materially reduce the luminosity of the tubes.

This difficulty has been overcome by taking advantage of the phenomenon discovered by Dewar, that charcoal is extremely efficient in absorbing gases near their point of liquefaction. A bulb containing such charcoal and cooled with liquid air is made part of the system to be filled with neon at low pressure, and, after it has done its duty, is fused off, thus leaving the neon tube practically free from objectionable impurities.

M. Claude has succeeded in preparing neon tubes some 17 feet in length, which have had a life of 1,000 hours, thus equaling the best incandescent lamps. The tubes can be made in any desired shape, to follow the contours of the space to be illuminated.

Neon light has a beautiful pink color, and it is totally devoid of blue rays. For this reason blue objects appear black in neon light, and to overcome this it is necessary to combine it with incandescent or mercury vapor light where true color values are desired.

One ampere gives about 900 candles in a neon tube 6 meters long, at a rate of 0.72 watts per candle.

Inserting the copper electrodes into the ends of the tubes.

Charles William Eliot

President of the American Society for the Advancement of Science

By Marcus Benjamin, Ph.D.

In no department of learning has the development of knowledge in recent years been more conspicuous than in education. This is especially true in the United States. A greater knowledge of science has also come about in consequence of improved educational conditions. Appreciative of these facts, the American Association for the Advancement of Science created in 1906 a special section of education, and at the meeting held at Atlanta, last December, gladly called to the highest office in its gift America's foremost educator.

Charles William Eliot was born in Boston, Mass., on March 20, 1834, and was the only son of Samuel Atkins Eliot, and Mary Lyman Eliot. His father was a well-known importer in Boston, of which city he was also mayor in 1835-37, and his mother's father was a successful merchant in the East India trade.

His early education was received at private schools, from which, at ten years of age, he was transferred to the Boston Public Latin School, then under the direction of Epes Sargent Dixwell. Ten years later he entered Harvard with the class of '53 and graduated in due course, standing second in his class.

In the winter following his graduation, he returned to Harvard as tutor in mathematics, and with his classmate, James Mills Peirce, who had received a similar appointment, began a life-long work as an educator, President Walker having urged upon him "to aim at the career of a college teacher." He was promoted to an assistant professorship in mathematics and chemistry in 1858, and two years later was given charge of the chemical laboratory of the Lawrence Scientific School, where he remained until the summer of 1863.

Two years abroad followed with periods of study in England, France, and Germany, during which he devoted special attention to the organization of technical schools and the prevailing methods of teaching chemistry and physics. It was by this experience that he unconsciously fitted himself for the acceptance of a professorship in chemistry in the Massachusetts Institute of Technology, then recently organized, to which he was called in 1865 by William B. Rogers, its founder and president. Here he remained for five years, organizing and developing the chemical department of that famous institution. Those years will never be forgotten so long as his Manual of Inorganic Chemistry (1866) and his Manual of Qualitative Chemical Analysis (1869) are used as text books, while his epoch-making influence in the study of chemistry will continue for all time.

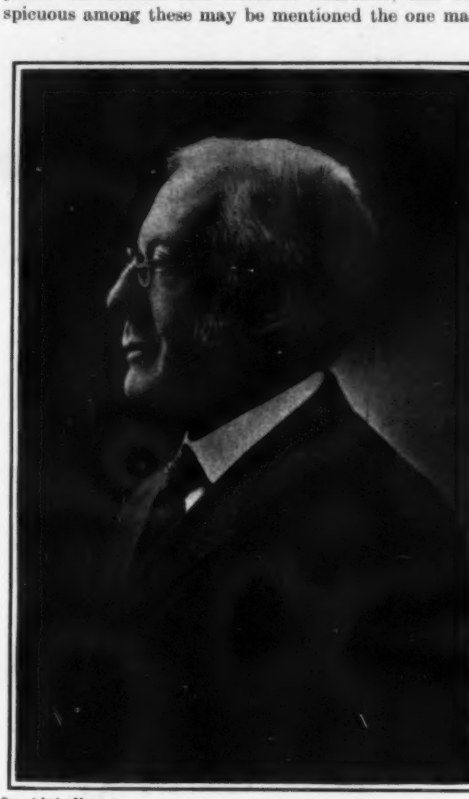
The valuable results achieved during his connection with the Massachusetts Institute of Technology gave him a high reputation both as a teacher and as an administrator, while his articles in the *Atlantic Monthly* on The New Education clearly demonstrated that a new power had arisen in the domain of education. The selection of the Board of Overseers of Harvard had long been vested in the state legislature, but in 1865 that function was transferred to the alumni, and it was believed that the time had come when the curriculum could be improved. In 1869 Mr. Eliot was elected to the presidency of the Alma Mater in succession to Dr. Thomas Hill, and so continued until 1909. He at once began a series of changes that have supplanted the old-fashioned prescribed course of study by an elective system, until more and more Harvard has come to resemble the great European universities.

Of these changes he says: "For the first 20 years progress was made through continuous struggle against the resistance of many wise and honorable persons, both within and without the university," but thereafter "there was much less conflict; because the ideals of the group of active workers to which I belonged became the ideals of a considerable majority of the friends of the University." The details of the progress cannot be given here, but they may be seen in the annual reports made by him as president of Harvard College to the Board of Overseers, the first of which was presented in 1870, and the last in 1909 for the years 1907-08. These it is said "have ranked among the most valuable contributions to the literature of higher education."

Seldom indeed has it been given to any man to so successfully achieve the ambitions of his earlier years.

As years have come to him, public recognition of the good results of his labors have been his. Williams and Princeton in 1869, Yale in 1870, Johns Hopkins in 1902, Tulane, Missouri, and Dartmouth in 1909, have given him the degree of LL.D., and Breslau in 1911 conferred upon him the degree of Ph.D. His own Harvard, on his retirement in June, 1909, not only crowned his faithful labors with the doctorate in laws, but bestowed upon him the unusual honorary doctorate in medicine "for his persistent, powerful, and courageous help in accomplishing the extraordinary reforms in medical education." Nor have foreign nations failed to recognize his educational work. In 1903 France conferred on him the insignia of an officer of the Legion of Honor. A year later he was made a corresponding member of the French Academy of Moral and Political Sciences. In 1908 he received the insignia of Grand Officer of the Crown of Italy, and in 1909 the Royal Order of the Prussian Crown, and the Imperial Order of the Rising Sun of Japan, these three decorations being all of the first class.

His wonderful gift of lucid statement and persuasive eloquence has naturally led to his being in demand for public educational and scientific addresses, and conspicuous among these may be mentioned the one made at the installation of Daniel C. Gilman as president of the Johns Hopkins University, and the one at the opening of the American Museum of Natural History in New York. While these addresses have been largely, as he says, of "an ephemeral nature or related to some question which was temporarily interesting the community or the institution where I was speaking," nevertheless they have had a mighty influence on molding public opinion, for his utterances were the result of deep thought and therefore carried conviction with them.



Copyright by Marceau.

Charles W. Eliot,

President of the American Society for the Advancement of Science.

In the United States his interests in various organizations has always been sought and there are but few of which he has not been a member. His name is among the fellows of the American Academy of Arts and Sciences, and he is also a member of the Massachusetts Historical Society. The American Philosophical Society, the oldest scientific organization in this country, has long had his name on its rolls, while the National Education Association of the United States and the National Conservation Association have been fortunate in having him as their president.

In addition to those already mentioned, his printed writings include the following books: Five American Contributions to Civilization and other Essays (1897); Charles Eliot, Landscape Architect (1902); John Gilley (1904); The Happy Life (1905); Four American Leaders (1906); and The Durable Satisfaction of Life (1910). These have been contributions to discussions which were of importance at the moment and not likely to be of permanent interest. Of them he writes: "Three of my books—two very small—may have some durability: The Happy Life; John Gilley, and Charles Eliot, Landscape Architect."

Since his retirement from the presidency of Harvard University, he has continued to work for certain public interests closely related to each other, which have long engaged his attention and which he believes to be of fundamental concern to democratic society. He says of them: "The chief of these interests are education, civil-service reform, municipal reform, capitalism and unionism in a democracy, preventive medicine, and conservation. They all relate to the building up, under free institutions, of sound character in the individual citizen and in the nation." The most conspicuous of these undertakings was perhaps his trip around the world during 1911-12 in the service of the Carnegie Endowment for International Peace, and the fruits of which were given to the world in 1914 under the title of "Some Roads Toward Peace," being a report to the trustees of the Endowment on observations made in China and Japan in 1912.

His connection with the American Association is of recent date, for he does not appear to have joined the organization until the third Boston meeting in 1909, but his powerful influence soon made itself felt and the Association promptly availed itself at the earliest opportunity of recognizing his high standing by electing him its president.

Quick Mending of Broken Bones

Within the last few years several ingenious methods of handling fractures have been announced that have greatly shortened the time required for the knitting together of the fractured parts resulting in more rapid recovery from this class of accidents; and it was only recently that what was considered a wonderful improvement was made public by the process of joining the ends of a fracture by means of a splint of bone that not only spliced the parts together, but supplied a nucleus for the formation of new material that would make a permanent union. This operation, however, necessitated an incision, and considerable work on the bones themselves. Now another method of treating fractures has been announced by Dr. H. J. Kauffer, a New York dentist, and consulting oral surgeon to the Harlem Hospital, which promises to produce wonderful results, and it can be applied in many minor but important cases, where it would be difficult to use other of the newer methods. In Dr. Kauffer's process he dries and grinds to powder a piece of fresh bone, and this powder he mixes to the consistency of a paste with petrolatum, and properly sterilizes the mixture. After the ends of the fractured bone have been brought into proper relations and the location ascertained by digital examination and X-ray, a syringe having a long needle is filled with the warmed bone mixture, and the needle is inserted to the seat of the fracture, and as deeply as possible between the fractured ends. The contents of the needle are then injected as the needle is slowly withdrawn to the surface of the bone, when the injection must stop. This procedure may be repeated several times at different angles, thus filling the entire space between the fractured ends with the petrolatum and bone cells, which act as a focus for the formation of new bone. The powdered bone and petrolatum is also recommended wherever bone is required. The powdered bone is stated to invite calcerous deposits and encourages the transformation of the adjacent tissue cells into bone. The announcement of this new method of procedure, which is made in the New York *Medical Journal*, is but a brief advance notice, and the complete paper giving results attained will be looked for with interest.

Effect of Impurities in Zinc

It has long been known that impurities, such as foreign metals, in zinc, greatly affects the ease with which it can be rolled, and from a series of experiments recently made in Europe it appears that cadmium is harmful above 0.25 per cent, while with 0.5 per cent rolling is impossible. Arsenic, 0.02 per cent, markedly increases the hardness, and with 0.03 per cent the metal is too brittle for practical purposes. Antimony is less objectionable than arsenic, as 0.07 per cent does not increase the hardness; but 0.02 per cent is enough to produce a striated surface on the rolled sheet, which makes it unsalable. Tin is objectionable when over 0.01, and prohibitive at 0.03 per cent. Copper does not harden until it reaches 0.08, and with 0.19 per cent the zinc is unworkable. A permissible maximum of iron is 0.12 per cent, but this is easily reduced in refining. Though 1 to 1.25 per cent of lead does not interfere with the rolling, a slight increase not only serious affects the malleability, but the excess of lead remains unalloyed and forms patches on the sheet. The presence of two or more impurities together results in a combination of the injurious effects of each.

Artificial Daylight—II*

Light Sources Suitable for Color-Matching

By Herbert E. Ives

Concluded from SCIENTIFIC AMERICAN SUPPLEMENT No. 2033, Page 398, December 19, 1914

THE PRACTICAL ACHIEVEMENT OF ARTIFICIAL DAYLIGHT.

BEFORE proceeding to an account of various artificial daylights let us here review briefly the pertinent facts about daylight and color. We have seen that daylight is variable, but that it always lies in a class apart from

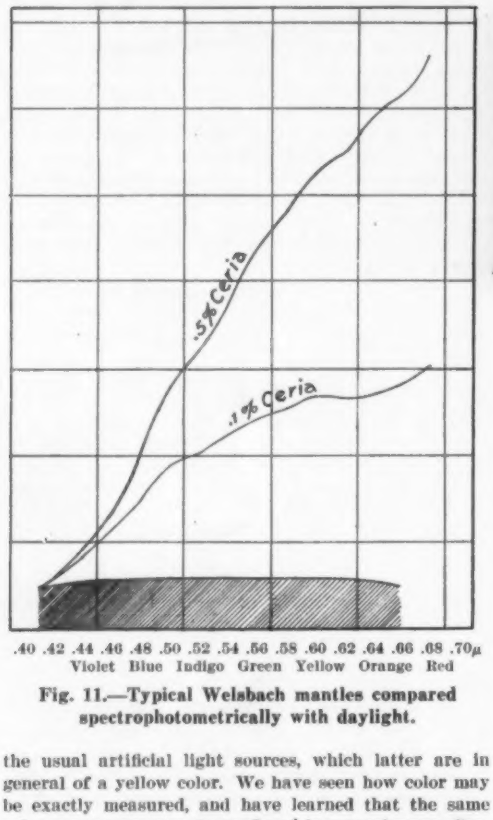


Fig. 11.—Typical Welsbach mantles compared spectrophotometrically with daylight.

the usual artificial light sources, which latter are in general of a yellow color. We have seen how color may be exactly measured, and have learned that the same color appearance may be produced in several ways. Several theoretical ways of producing artificial daylight have been described. Finally, by investigating the changes in the apparent color of objects under different colors of light, we have been led to formulate the essential characteristic of artificial daylight; namely, it must not only look like daylight, but also be like it, as shown by an analysis of the spectrum.

In approaching the practical side of the problem it becomes necessary to choose a standard for daylight, and it becomes necessary to know what degree of approximation to the last-named criterion is sufficient for practical purposes. It is also necessary to pay attention to the matter of efficiency—the artificial daylight must not be prohibitive in cost.

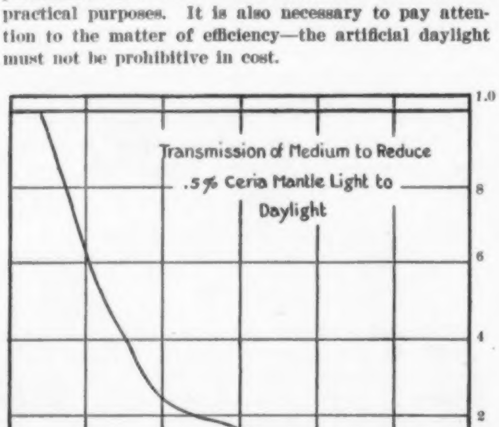


Fig. 14.—Transmission of medium to reduce light from 0.5 per cent ceria mantle to daylight.

The standard of white light adopted by the writer is derived from the mean of a large number of spectrophotometric determinations of sunlight quoted above, into which an additional factor has been introduced. It is always desirable to connect any standard with other standards; to depend not on a set of numerical values, but on some simple mathematical expression which may be developed by the introduction of a few con-

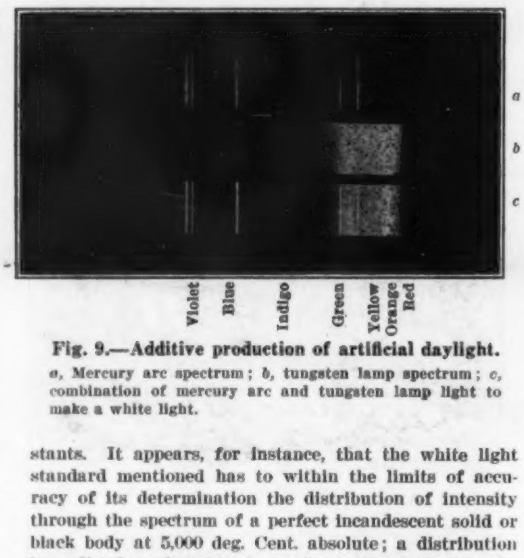


Fig. 9.—Additive production of artificial daylight.
a, Mercury arc spectrum; *b*, tungsten lamp spectrum; *c*, combination of mercury arc and tungsten lamp light to make a white light.

stants. It appears, for instance, that the white light standard mentioned has to within the limits of accuracy of its determination the distribution of intensity through the spectrum of a perfect incandescent solid or black body at 5,000 deg. Cent. absolute; a distribution immediately calculable from the laws of black body radiation. So much for a scientific standpoint. In

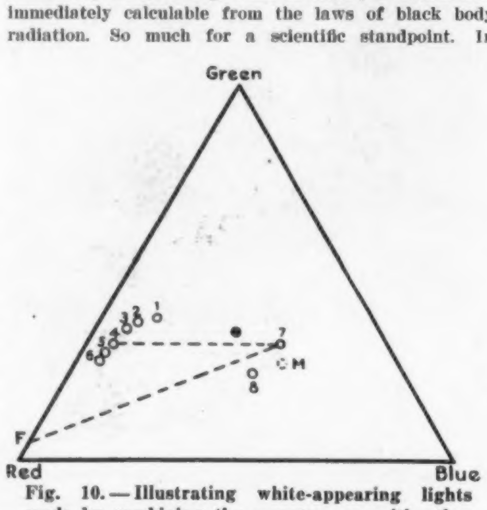


Fig. 10.—Illustrating white-appearing lights made by combining the mercury arc with other illuminants.
1, 2, and 3. Welsbach mantles; 4, tungsten lamp; 5 and 6, tantalum and carbon lamps; 7, mercury arc; *F*, color of fluorescent reflector; 8, mixture of mercury light from lamp and reflector (*M*) with *F*.

commercial practice another fact has had to be given weight; namely, professional color matchers have chosen as their standard light the blue north sky. It is difficult to change the customs of experts, and so it became practically necessary to supply a blue sky standard. For this the spectrophotometer values given in Fig. 2 serve as a basis.

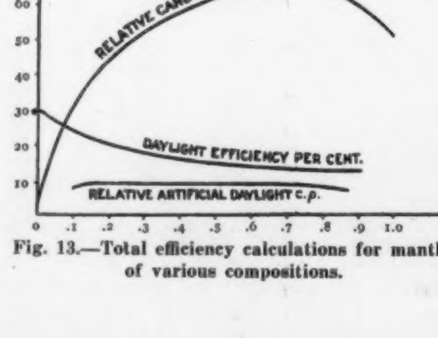


Fig. 13.—Total efficiency calculations for mantles of various compositions.

How closely is it necessary in practice to approximate the exact spectrum distribution of daylight? Very closely indeed, but not so exactly as to be prohibitively difficult, for this reason: that all ordinary colored objects and coloring materials have rather long diffuse

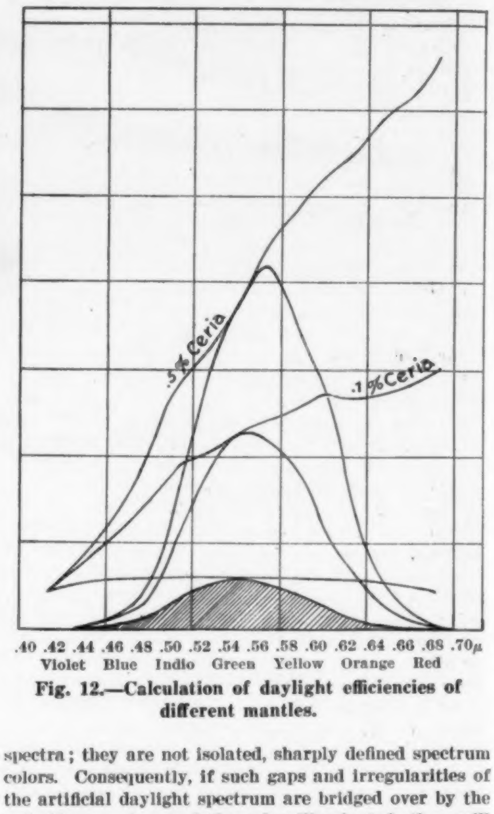


Fig. 12.—Calculation of daylight efficiencies of different mantles.

spectra; they are not isolated, sharply defined spectrum colors. Consequently, if such gaps and irregularities of the artificial daylight spectrum are bridged over by the reflection spectrum of the color illuminated, they will not be noted. For instance, an illuminant whose spectrum consisted of twenty-five or thirty equally spaced lines would probably behave excellently as a color-matching light, provided, of course, their intensity was closely that of the daylight spectrum at each point. An expert with a knowledge of the spectrum and of the kind of coloring media used in the arts can make up critical colors having several maxima of reflecting power in the spectrum, colors which match under one light but not under another, and from the accumulated

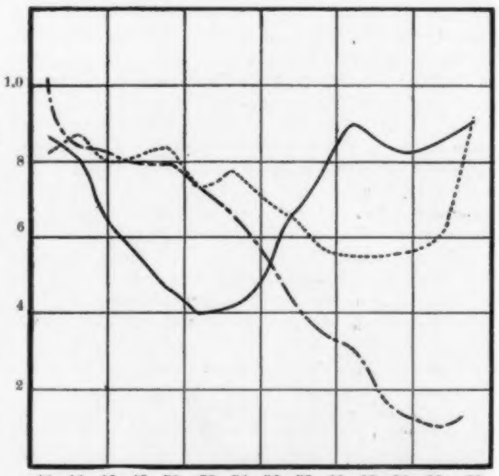


Fig. 15.—Transmission curves of representative glasses and dyes.

experience of the practical dyer other colors may be found of similar difficult character. The behavior of these colors under an artificial daylight in its experimental stages provides valuable information and guidance.

The question of efficiency will be considered in connection with each of the three kinds of artificial daylight described below.

*Paper read before the Franklin Institute and published in its *Journal*.

The first kind of artificial daylight postulated as possible is a light source that has naturally the same spectrum distribution of intensity as daylight. An incandescent black body at 5,000 deg. Cent. absolute would have this distribution, but such a temperature is entirely beyond our present means. The same distribution could be obtained at much lower temperatures if we had available a selectively radiating substance which would give out a comparatively small amount of invisible heat radiation and have a much greater emissivity at the blue end of the spectrum than at the red. Such a substance is not yet known, but the materials used in the Welsbach mantle approximate the characteristics to a degree which incites us to further study of these oxides. Another possible way of achieving this spectrum distribution is through non-temperature radiations, as, for instance, by the passage of a current of electricity through a rarefied gas which would radiate at a sufficient number of wave-lengths in the right proportion. Such an artificial daylight has been found in the radiation from the carbon dioxide vacuum tube, which under the name of the Moore tube has been developed commercially and has deservedly been used to considerable extent for color-matching work. Its spectrum consists of many fine lines and bands, together giving the color of a light blue sky and of reasonable uniform intensity. The Moore tube is, however, comparatively inefficient, and demands an expensive installation of alternating current and transformer to produce high potential—drawbacks which have prevented its extensive use.

The second kind of artificial daylight I wish to treat of here is one of interest from the standpoint of color measurement and theory. So far as concerns the question of color matching, this particular daylight—namely, the one made by matching pairs of colors to look like daylight—is chiefly of importance as illustrating the pitfalls to be avoided.

A property of the color triangle above referred to is that colors lying on opposite sides of a line passing through the center of the triangle (white) mix to produce all colors lying on that line, among them white. Consequently, if two happen to lie thus on opposite ends of a line through the center of the color triangle, it should be possible to make a white-appearing mixture. Examination of the color triangle, Fig. 10, shows that the mercury vapor arc lies opposite the tungsten lamp. Consequently, if these two illuminants act together the appearance should be that of white light. Such is, in fact, the case. White-appearing light can be so produced at an efficiency somewhere between that of the two constituents, and white light of this constitution is to be found in several places. The term "additive" production of artificial daylight may be applied to this process to distinguish it from the other process presently to be described as "subtractive." This particular "additive" daylight, and others which are apt to be produced experimentally in efforts to make a true artificial daylight, are characterized by their failure to show up colors in their true daylight appearance. The reason for the failure of this particular combination is easily seen from the spectrograms of Fig. 9, where the tungsten lamp spectrum is shown, with its deficiency in blue; the mercury arc spectrum, deficient in red, and the combination of the two. The latter is characterized by long gaps and irregularities. The mercury arc-tungsten combination is not, therefore, suited for one use to which it has been mistakenly put; namely, the illumination of picture galleries.

Another example of this additive method of producing white light is furnished by the Cooper-Hewitt lamp with fluorescent reflector. The fluorescent substance—rhodamine—is of a color approximately complementary to the hue of the mercury arc, as is shown in the color triangle of Fig. 10, where the fluorescent light is shown at *F*, the mercury arc at 7, and the "white" light at 8.

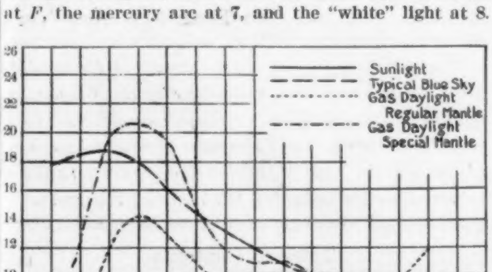


Fig. 17.—Spectrophotometric curves of natural and artificial daylight.

This is not exactly on the line joining 7 and *F*, because the mercury arc light reflected from the rhodamine reflector is deficient in green. The real mixture is between *F* and *M*. It will be seen that the resultant color is a purplish-white (below center of the triangle). This light is, unfortunately, not suited for delicate color matching, because its spectrum is merely the mercury lines with an orange-red band added. Large portions of the spectrum are missing.

Fig. 16.—Color-matching booth.

Fig. 18.—Manner of using daylight spectacles.

The next, and on the whole the most important, method of producing artificial daylight is the subtractive one; that is, the subtraction by absorption of those radiations which an illuminant emits in excess over daylight.

By way of detailed explanation, let us now carry through the various steps in the practical production of such an artificial daylight. Let us take as our illuminant to be transformed to daylight the Welsbach mantle, which, because of its nearer approach to whiteness than the usual incandescent solids, especially recommends itself for the purpose. The first step is to determine its distribution of intensity throughout the spectrum and compare it to that of daylight. At once cognizance must be taken of the fact that the color (intensity distribution) of a mantle depends upon the composition. A pure thoria mantle is much whiter than a mantle of pure ceria, the light of the latter being, in fact, deep orange-yellow. Fig. 11 shows the energy distribution of two typical mantles, containing 0.25 per cent and 0.50 per cent ceria respectively, each compared with daylight under such conditions that the intensity at the extreme blue end of the spectrum is equal. When these data are so plotted the space between the mantle curves and the daylight curve represents light which must be absorbed. It is obvious that the whiter the mantle (i. e., the smaller the percentage of ceria) the less light must be absorbed in order to leave daylight. As yet, however, the amount of this absorption is not expressible in useful comparative units. It is necessary to express this in terms of luminosity. This is done by replotting the data of Fig. 11, multiplying the value at each wave-length by the relative brightness of that kind of radiation as is done in Fig. 12. Now the area of the "white" luminosity curve, compared to the area of the mantle curve, gives us at once the relative amount of light left after the subtraction process. This ratio I have called the "daylight efficiency." Its value for mantles of various percentages of ceria is plotted at curve *a*, Fig. 13. Other things being equal, it is clear that the mantle with no ceria should be chosen. But other things are not equal, for with varying percentages of ceria the candle-power of a mantle changes, rising from a minimum for the pure ceria to a maximum for a mixture of 99 per cent ceria and 1 per cent of thoria, then again decreasing as the ceria content is increased. This curve of relative candle-power is also shown in Fig. 13. It is obvious that the product of curves *a* and *b* will give the total daylight efficiency of all mantles when screened to make artificial daylight. This product is shown in curve *c* interesting, as showing that mantles through quite a range of composition—from 0.25 per cent to 0.7 per cent ceria—can yield the same efficiency of artificial daylight. Above 0.7 per cent ceria the efficiency drops off rapidly. This efficiency is only about 15 per cent, showing that artificial daylight is necessarily an expensive product when thus secured.

Having chosen a mantle to be screened, the next question is that of absorbing media. What is the absorption needed? Putting it in terms of transmission it is this: The transmission at each wave-length must be the ratio of the daylight intensity to the artificial light intensity when so represented that the value is unity for the extreme end of the spectrum. The transmission required to transform the light of the Welsbach mantle of 0.5 per cent ceria to "white" (black body at 5,000 deg. Cent. absolute) is shown in Fig. 14. It appears that the absorbing medium indicated is of general blue color. The next step is to study the various available absorbing media. These are practically reduced to two: first, colored glass, and, second, dyes which may be incorporated in gelatine or some similar transparent carrier. No single glass or combination of glasses at present on the market possesses the absorption called for. Cobalt blue glass, which is the first thought of everyone, has several irregular bands, not a uniformly increasing transmission toward the blue end of the spectrum. Copper glass, which is blue-green in color, has a gradual absorption, but is too green. The great advantages of glass over dyed gelatine are its permanence and the possibility of working into all shapes, from flat sheet to spherical enclosure. Still, dyes have the one advantage that they provide an enormous number of absorptions of both broad and narrow types. Some representative transmissions are shown in Fig. 15. The bands and deficiencies of glasses can almost always be filled in by properly chosen dyes, although many dyes are not at all permanent, which reduces very materially the number available.

It has been found possible to make a practical combination of copper glass in sheet form with a dyed gelatine layer on a separate sheet, which accomplishes the purpose admirably, using dyes of great permanence. The commercial device is shown in Fig. 16. It consists of a small booth, closed at back and sides, in order that stray light from other light sources may not enter and mix with the daylight. Samples of cloth, tobacco, etc., are held under the glasses, and the result is identical with daylight. The spectrophotometer intensity curve is shown in Fig. 17, both for an 0.7 per cent ceria mantle, which gives the sunlight color, and for an 0.25 per cent ceria mantle, which gives the north light used by dyers and color matchers.

With the 0.25 per cent upright mantle more than 20 foot-candles illumination is obtained on the working

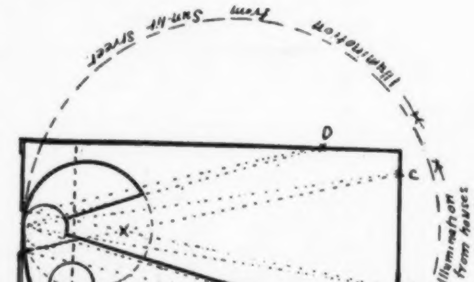


Fig. 19.—The distribution of daylight from a window.

plane, while with a large inverted mantle the figure is multiplied by four—in either case sufficient for color-matching purposes. The absorption of light by the glasses is about 90 per cent. The device has been worked out in the booth form partly because the expense of lighting large areas would be excessive, were there not some good reason for so doing, which often there is not, and partly to educate the user to exclude stray light of other colors which would distort his color values. These devices are now being used extensively in silk mills, cigar factories, department stores, etc.

A limitation to this form is its lack of flexibility, caused by the necessity for using dyed gelatine, which can be laid down only on a flat plate. The extreme desirability of effecting the entire absorption through glass has long been apparent, and in the Research Laboratories of The United Gas Improvement Company a small experimental glass plant has been actively engaged in the problem of producing such glass. All known coloring oxides have been studied, and Mr. Edw. J. Brady, in charge of this particular research, has recently succeeded in producing a true daylight glass. This glass will shortly be available for gas and other illuminants, and will make artificial daylight as easy to produce as any other artificial light—necessarily at a large cost, to be sure; but in many cases this large cost will be an insignificant item compared with the twelve or more additional working hours furnished by artificial daylight.

Before leaving this subject of the production of light, having a daylight color, one of the methods of using the absorbing medium claims attention. Colored objects, it must be remembered, owe their color to the effect on the light incident upon and reflected from them. Now, it is immaterial whether the light is subjected to the day-color producing absorption before or after its incidence on the colored object. Except for considerations of convenience, the absorbing glasses could just as well be placed vertically in front of the booth in Fig. 16, and the colored samples placed in the direct light of the illuminant. Advantage is taken of this alternative possibility in the construction of the daylight spectacles, shown in Fig. 18. Built with a perfectly light-excluding hood, these may be worn by the surgeon or the color matcher, and when used with the appropriate light source they produce daylight for him alone, thus obviating the necessity for a special booth or room in which to do his work. Further advantages of this form of color-matching device are the small amount of special glass needed and the entire freedom from questions of breakage through overheating.

THE COST OF A COMPLETE COPY OF DAYLIGHT.

The question always asked about artificial daylight is: How much does it cost to make a complete copy of daylight illumination in a room? Some figures which I have given elsewhere in connection with a study of the distribution of daylight may, therefore, be of interest here. Pleasant daylighting of the room taken for study, a room 16 feet by 10 feet, was produced when the light of the sky illuminated the whole floor of the room and when the ceiling was illuminated by the light reflected from the street below, while the opposite houses, which were in shadow, were the only outside objects visible to the occupants of the room. The bright sky, which does most of the lighting of the room, forms a concealed light source. The distribution of light from the window as a light source is shown in elevation in Fig. 19. It was found possible by a construction of mirrors to closely duplicate this distribution and to produce an illumination about one tenth that of real daylight at an expenditure of about 260 watts. To secure daylight intensity would have taken 2,000 watts, whereas if the light had all been subjected to daylight-producing absorption it would have required 20,000 watts.

If, however, daylight could be produced directly in an illuminant without any waste heat radiation, it would not only be a much more efficient process than that indicated, but even more efficient than any present known artificial light source. Instead of 20,000 watts, 50 watts would suffice.

The ultimate goal of the student of artificial daylight, therefore, is the production of daylight whenever and wherever it is wanted, distributed in any desired manner, at no greater cost than our present yellow artificial light.

The Absorptive Power of Myelin Liquid Crystals

By B. O. Lehmann

The growth of the "apparently living" myelin crystals is, as I have already shown, in no way related to that of Traube's artificial cells, where increase in size is due to internal osmotic pressure of the contained fluid. Indeed, the myelin forms are in general solid, containing no foreign fluid. Furthermore, I have proven that even the hollow myelin forms of phrenosin and protagon do not grow by osmosis, increasing as they do equally well when open at one end as when entirely closed. When open they elongate by the swelling due to the taking up of water molecules into loose chemical combination, and hence suck water into the lumen on the same principle that a bicycle pump sucks in air. Sudden shortening, due to lowering of temperature, ejects a corresponding amount of water (Figs. 1 and 2). In the same way a hollow myelin form may suck in and throw out one or more smaller forms.

The discovery of this absorptive power gives the long-sought explanation of the origin of the long thread-like and tubular myelin shapes arising when a substance swells in a liquid in which it is insoluble. For example, allow a thin film of phrenosin to dry on a slide, then introduce fresh water under the cover glass. First wart-like elevations appear here and there (Fig. 3) with corresponding depressions beneath them. By sucking up water these warts elongate into hollow threads, finally breaking away from the mass by contraction (Figs. 3, 4 and 5). If the film is closely adjacent to the

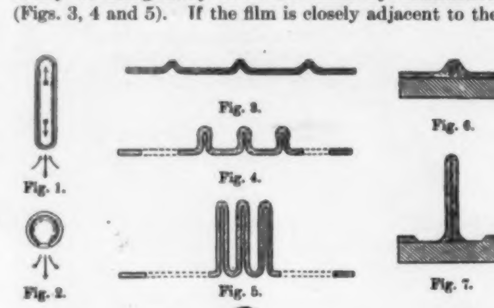


Fig. 1. Fig. 2. Fig. 3. Fig. 4. Fig. 5. Fig. 6. Fig. 7.

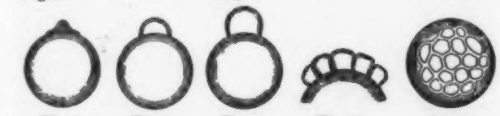


Fig. 8. Fig. 9. Fig. 10. Fig. 11. Fig. 12.

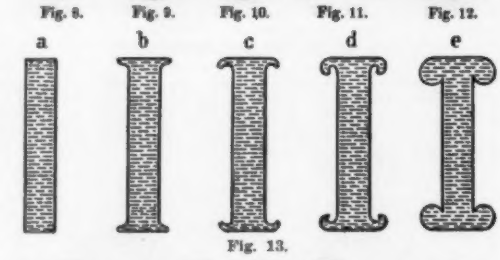


Fig. 13.

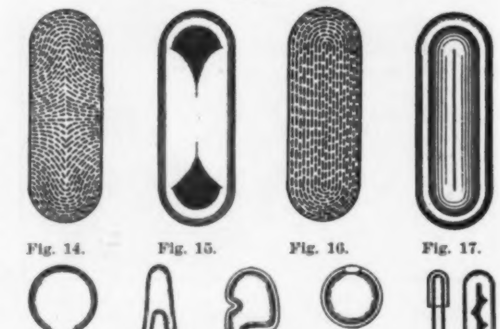


Fig. 14. Fig. 15. Fig. 16. Fig. 17.

Fig. 18.

slide no water can be sucked into the warts and the threads will be solid (Figs. 6 and 7).

When these warts form on the surface of an air bubble the hair-like depressions at their bases are pulled apart, as the surface tension of the liquid crystaline mass is less than that of the water, and the interesting appearance shown in Figs. 8 to 12 is obtained.

All these phenomena are explainable by the expansion of the substance through swelling, in combination with mechanical anisotrophy (*anisotropie*), that is, the ability of the tablet-shaped molecules easily to glide over one another in a direction parallel to their surfaces, but not in a direction perpendicular to them. Absorption therefore causes increase in length, not in thickness. Twisting motion occurs through the uneven absorption, and by constriction division may result.

The myelin forms of para-azo-oxy-cinnamic-acid-ethyl-aester illustrate the above-described absorptive force. These assume, when a proper solvent is selected, semi-isotropic cylindrical forms, whose ends are plane surfaces. With sinking temperature these crystals absorb the solvent first at the ends, and the parallel gliding of the molecules occasions the appearances shown in Fig. 13 *a-e*. If there are conical structural disturbances at the ends (Fig. 14), then in ordinary light the appearance is that shown in Fig. 15.

If the plate-like molecules are grouped in co-axial cylinders around the axis, then the ends are formed as shown in Fig. 16, and Fig. 17 gives the appearance in natural light.

The peculiar shapes these absorptive liquid crystals assume, their elongation into long threads by the inflowing of liquid, the putting out of buds and swellings along these threads, the laminations resultant on the sucking in of smaller forms by larger (see Fig. 18), are extremely suggestive of similar phenomena seen in living organisms, and the analogy, being unique, is of the more value.

The minute study of form, structure and manifestation of energy of myelin forms promises to be of profound import to the understanding of the functions of living organisms; we are in the borderland between physics and physiology, already a realm of grand proportions.

*Translated from *Annalen der Physik* for the SCIENTIFIC AMERICAN SUPPLEMENT.

Roads Built in 1914.—At the American Road Congress, recently held at Atlanta, it was stated that more than 18,000 miles of hard surfaced roads were built in 1914, and that the annual expenditure in this country for roads now amounts to $205,000,000 a year. It is appreciated, however, that there is great carelessness in this work, and it was pointed out that efficient management would effect a saving of at least 25 per cent, with a probable improvement in the character of the work done.

SCIENTIFIC AMERICAN SUPPLEMENT

Founded 1876

NEW YORK, SATURDAY, DECEMBER 26, 1914

Published weekly by Munn & Company, Incorporated
Charles Allen Munn, President; Frederick Converse Beach, Secretary; Orson D. Munn, Treasurer
all at 361 Broadway, New York

Entered at Post Office of New York, N. Y., as Second Class Matter

The Scientific American Publications

Scientific American Supplement (established 1876) per year	$5.00
Scientific American (established 1845) . . . . "	3.00
American Homes and Gardens . . . . "	3.00

The combined subscription rates and rates to foreign countries, including Canada, will be furnished upon application

Remit by postal or express money order, bank draft or check

Munn & Co., Inc., 361 Broadway, New York

The purpose of the Supplement is to publish the more important announcements of distinguished technologists, to digest significant articles that appear in European publications, and altogether to reflect the most advanced thought in science and industry throughout the world.

Table of Contents

The Scientific American Supplement Index for Vol. 78

JULY—DECEMBER, 1914

THE * INDICATES THAT THE ARTICLE IS ILLUSTRATED

A

B

C

D

E

F

G

H